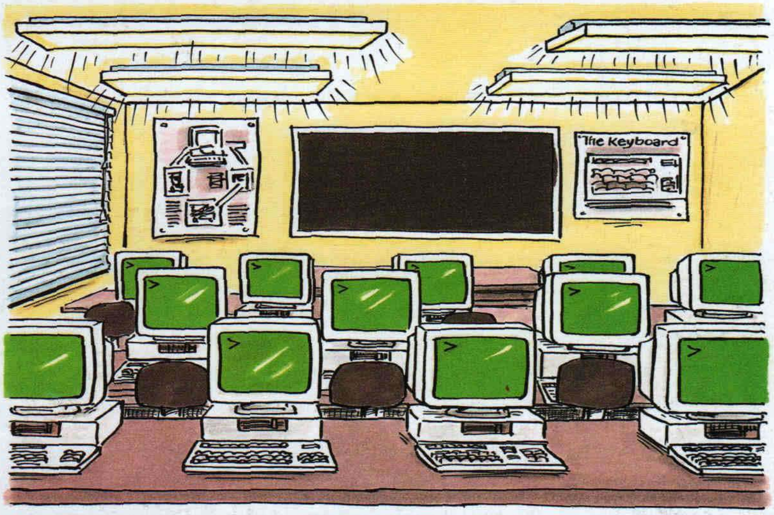
Guide 28

Saving energy in schools

A guide on lighting and IT equipment for headteachers, governors and school staff

This Guide helps you to identify where much of the school's electricity is used by:

- describing how to calculate the electrical consumption of a school's lighting installation and showing how efficient your lighting is compared to more modern energy efficient installations, and
- providing guidelines on the electricity consumed by typical Information Technology (IT), and other office type equipment used in schools.



Are lights and equipment left on unnecessarily in your school?

Few schools are able to tell from looking at their electricity bills and meters how much power is consumed by lighting, how much by IT equipment and how much for other purposes.

This Guide helps the busy School Energy Manager or Caretaker to calculate the installed electrical load of their school. It also provides Governors and Headteachers with guidance on how to improve their lighting efficiency, the technical considerations and typical payback periods.

Electricity is an expensive fuel, costing about four times as much per kWh as gas, oil and coal. As well as being expensive, electricity also produces some three times as much CO2 as fossil fuels, per useful kWh supplied. Electricity accounts for about 40 to 45% of the total energy costs in a typical school, of which over half is normally spent on lighting, with IT equipment typically consuming between a third and a half of the remainder. In the UK about 35% of carbon dioxide emissions come from fossil fuel burning power stations. Reducing your electrical consumption will not only reduce your energy bill, but will also reduce the effect on the environment.

Focusing good housekeeping activities on cutting electricity consumption (for example, by switching off lights and equipment when not needed) can achieve worthwhile energy cost savings without the need for capital expenditure.

Comparing your lighting and IT costs

A useful and revealing way of comparing your lighting and IT energy consumption is to consider:

- the relative energy ratings of your lighting installation and IT equipment, (ie the installed load) and
- the length of time they are switched on.

By breaking down the energy consumption in this way, the scope for making improvements and savings becomes much more apparent. It is worth remembering that:

POWER x TIME x UNIT PRICE = COST

A reduction in either POWER, TIME or UNIT PRICE will lower energy COSTS.
For example:

- changing to a more efficient lamp type, will reduce POWER consumption
- switching off lights when daylight alone is adequate, or switching off equipment when no longer in use will reduce the TIME that electricity is being used
- ensuring you are on the appropriate tariff will minimise the UNIT PRICE you pay for electricity.

All these aspects are within a school's control and will result in lower energy COSTS.

> *“Avoiding unnecessary lighting and IT use saves money as well as being a visible sign of good management.”*

BEST PRACTICE PROGRAMME

Energy Efficiency Office
DEPARTMENT OF THE ENVIRONMENT

LIGHTING

Lighting – the installed load

The performance of lighting schemes can be compared by calculating their 'installed load'. The installed load is simply the total electrical rating of all the light fittings in a room or building divided by the floor area. The box on the right explains how to calculate the installed load and gives a worked example.

Diagram 1 shows typical consumptions for a range of lighting installations commonly used in schools. You can use it to see how your school's lighting compares with similar lighting installations, or to estimate the likely savings of a proposed new lighting scheme. The diagram shows a range of installed loads rather than single values, because many factors affect the design of a lighting installation:

- the reflectance of the surfaces (walls, floor, ceiling and furniture) – lighter colours reflect, darker colours absorb more light
- light fittings differ in their light distribution and efficiencies
- the light output from each type of lamp varies with its power, age, colour rendering qualities and manufacturer.

To obtain the overall lighting consumption, the installed loads of the classrooms, corridors, assembly hall, staff rooms etc, should each be calculated in turn.

Hours of use – calculating the annual costs

Having calculated the installed load for each area of the school, the next step is to estimate the number of hours that the lights are switched on in each room.

How to calculate the installed load

To calculate the installed load for a particular room, add together the ratings (Watts) of all the lamps in the room and divide the total by the floor area (m^2) to give a loading in W/m^2.

Lamp wattages are normally printed on the lamp. For dual wattage fluorescent tubes (eg 65 W/80 W), use the lower rating unless the fittings are more than about 15 years old.

Correction factors

Correction factors have to be applied to some lamps to make an allowance for the energy used by the lamp control gear. For compact fluorescent lamps with their own control gear (ie the replacement type) and tungsten light bulbs, use the rated value printed on the lamp. For other lamps, refer to the manufacturer's data, or use the typical correction factors in the table below.

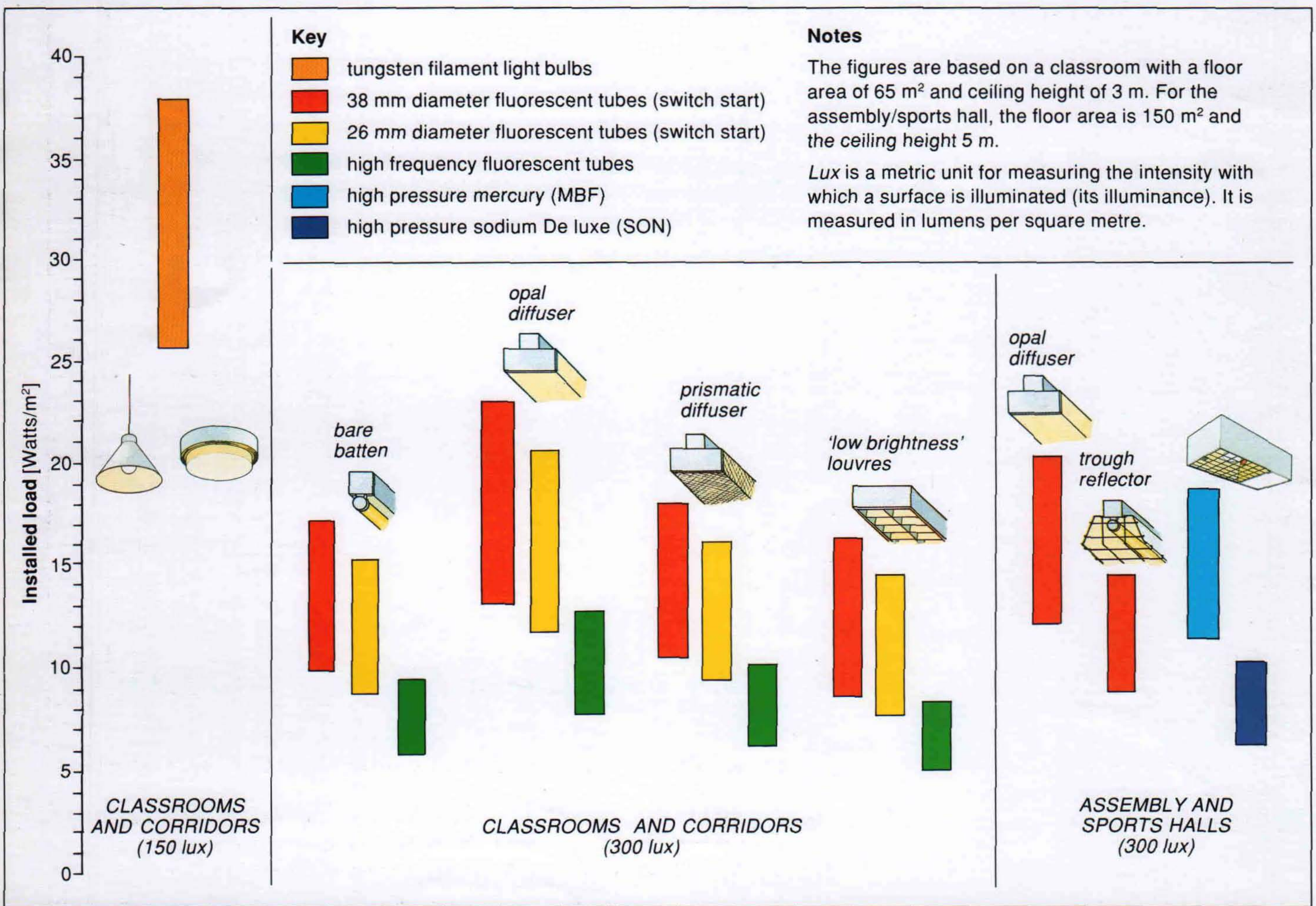
Lamp Type	Correction factor
Fluorescent tubes (except high frequency)	1.25
High frequency fluorescent tubes	1.12
Sodium, Mercury Fluorescent and Metal Halide lamps	1.10

Example

An assembly hall measures 34 m x 18 m. It has 50 recessed light fittings with opal diffusers. Each fitting contains four fluorescent tubes rated at 40 W.

Total lamp wattage (50 x 4 x 40) W	=	8 000 W
Correction factor (allowance for control gear) x 1.25	=	10 000 W
Area of space (34 x 18) m^2	=	612 m^2
Installed load (10 000/612) W/m^2	=	16.3 W/m^2

This compares with a typical range of 12 to 21 W/m^2 for fluorescent fittings.



Notes

The figures are based on a classroom with a floor area of 65 m^2 and ceiling height of 3 m. For the assembly/sports hall, the floor area is 150 m^2 and the ceiling height 5 m.

Lux is a metric unit for measuring the intensity with which a surface is illuminated (its illuminance). It is measured in lumens per square metre.

Diagram 1 Comparison of installed loads for typical light fittings

It will be easier to use Diagram 4 if you categorise the equipment under the headings listed. For monitors and dot matrix printers, this will involve noting the nameplate ratings marked on the equipment to determine which average power consumption figure to use from Diagram 4. The total number of running hours for each type of equipment can then be multiplied by the typical in-use consumption (indicated by the blue bars) to arrive at an estimate of the total energy consumed. (An example is shown in Table 3.)

IT equipment – looking for improvements and savings

Experience shows that much equipment gets switched on first thing in the morning and is left on all day, regardless of how much it is used. Where equipment has a long 'warm-up' time (such as a photocopier) and is used frequently throughout the day, such an approach may be acceptable – the time wasted in waiting for the copier to warm up each time would outweigh the value of the energy savings.

It would, however, be worth turning equipment off after use if it:

- has a short or negligible warm-up period, such as a typewriter and most daisywheel and dot matrix printers, or
- is not used for long periods.

When making a list of the IT equipment in your school, it would be worth enquiring about how frequently it is used as well as for how long it is switched on. You could then discuss with the users whether any worthwhile savings were possible without causing inconvenience.

For the school in Table 3, for example, it is clear that the main IT energy users are the computer rooms (70% of IT running costs) and the two photocopiers (18% of IT running costs).

Analysing the figures in Table 3, a number of possible savings look to be worth investigating.

- Could the computers and Visual Display Units (VDUs) in the computer rooms be switched off for part of the day? (It is normally worthwhile switching computers off if they are not going to be used for a whole lesson, or over break times, remembering to store any new data before switching off the computer.)
- Could the BBC computers with the new colour VDUs be used in preference to the older VDUs? (Generally, improvements in the design of electronic circuitry mean that modern equipment has lower running costs than similar but older equipment.)
- Could the dot matrix printers be switched off for more of the time? (Printers are often used for a few minutes each lesson and stand idle the rest of the time. Switching the printers off at the end of each lesson would save electricity with little inconvenience, as their 'warm-up' time is a few seconds.)

IT equipment	Number	Power consumption [W]	Hours of use per year [hr]	Energy * costs [£]
Computer rooms				
BBC computers	32	18	1600	65
Old colour VDU	16	95	1600	170
New colour VDU	16	50	1600	90
Dot matrix printers (0.75 amp)	16	50	1200	67
Rest of school				
IBM with hard disk	4	110	600	18
Laser printers	4	120	300	10
Old colour televisions	4	95	400	11
Typewriters (school office)	1	30	1000	2
Typewriters (classrooms)	20	30	400	17
Fax machine	1	14	8760	9
Photocopier (medium)	1	200	2000	28
Photocopier (large capacity)	1	500	2000	70
			Annual IT running costs	**£557**

* **To obtain the energy costs, multiply the number by the power consumption by the hours of use by the unit price of electricity (£0.07, divided by 1000). Eg 32 × 18 × 1600 × 0.07/1000 = £65. (£0.07 is the approximate price of 1 kWh of electricity – if you have a more precise figure, use it here. Dividing by 1000 converts Watts to kW). Note that consistency is more important than absolute accuracy.**

Table 3 Example of how to estimate annual IT running costs

- Could one of the photocopiers be switched off for part of the time? Using the medium size machine for most photocopying and only switching on the large machine for the occasionally heavy print runs would be worth investigating.

Further advice

There are many factors to consider when designing a new lighting scheme, or buying new IT equipment. This Guide has outlined the main considerations that affect running costs and set out to make you more informed about some of the available options. But when replacing or improving your present lighting installation you should seek professional advice. In particular, the lighting of rooms with computer screens needs great care if glare and troublesome reflections are to be avoided.

There are a number of sources that can offer advice.

- Your Local Authority's Energy Management Unit, if it has one, is usually a good source of informed and impartial advice. Ask whether your Local Authority has a rolling programme of maintenance or refurbishment into which you can include work that you want done at your school.
- All the regional electricity companies have advisory units that provide free advice.
- Your local lighting contractor and manufacturers of lighting equipment can also be helpful.

References

The following references contain more detailed information on lighting:

Guidelines for Environmental Design and Fuel Conservation in Educational Buildings, Design Note 17, published by the Department for Education. Contact the Publications Despatch Centre 081 952 2366.

A Guide to Energy Efficient Refurbishment (Maintenance and Renewal in Educational Buildings), Building Bulletin 73, Architects and Buildings Branch, Department for Education. HMSO ISBN 0-11-270772-6.

Energy Managers Lighting Handbook, Lighting Industry Federation Limited, Swan House, 207 Balham High Road, London SW17 7QB. Tel 081 675 5432.

Code for Interior Lighting and The Visual Environment in Lecture, Teaching and Conference Rooms (Lighting Guide 5) published by the Chartered Institution of Building Services Engineers, Delta House, 222 Balham High Road, London SW12 9BS. Tel: 081 675 5211.

Further information on this or other building-related projects, please contact: Enquiries Bureau, Building Research Energy Conservation Support Unit (BRECSU), Building Research Establishment, Garston, Watford, WD2 7JR. Tel No 0923 664258. Fax No 0923 664097.

For further information on industrial projects, please contact the Energy Efficiency Enquiries Bureau, Energy Technology Support Unit (ETSU), Building 156, Harwell Laboratory, Oxon OX11 0RA. Tel No 0235 436747. Telex No 83135. Fax No 0235 432923.

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This may be done by averaging the number of hours the lights are on each day and multiplying this by the number of days in the year that the room is in use. Note, however, lighting use will depend on the occupancy pattern and daylight availability, and hence is likely to vary with time of year. Having gathered all the information, the final step is to calculate the lighting costs for the whole school. This is most conveniently done in tabular form as shown in Table 1. This shows the annual lighting cost for a typical primary school. The lighting cost for a typical secondary school is likely to be four or five times more.

Lighting – looking for improvements and savings

There are two main ways that lighting costs can be reduced:

- reduce length of time lights are switched on
- install more efficient lighting.

Hours of use

Lighting consumes the most expensive fuel (electricity) when it is on, but does not cost anything when it is switched off. The biggest wastage of energy in lighting results from lights being used unnecessarily, for example, in rooms that are unoccupied or are well lit by daylight.

As most schools have manually controlled light switches, better control of lighting is literally in the hands of staff and pupils.

There is sufficient daylight available in most schools to meet lighting requirements for a significant part of the day, yet lighting is very frequently left on. It has been found that switching on lights first thing in the morning correlates closely with the level of daylight at the time. Lights are then unlikely to be turned off until the space is completely vacated, eg all pupils and the teacher leave the classroom, whether at break, lunchtime or the end of the day. Where the space is continuously occupied, eg library, or in common spaces such as corridors, the lighting may typically be left on all day, even when daylight levels are adequate. In many schools lights are rarely switched off until the end of the school day – sometimes they are left on for the cleaners. **Remember, lights should always be switched off when rooms are not in use, even for a short while. It is a myth that it is cheaper to leave lights on (eg over playtime) than to switch them off.**

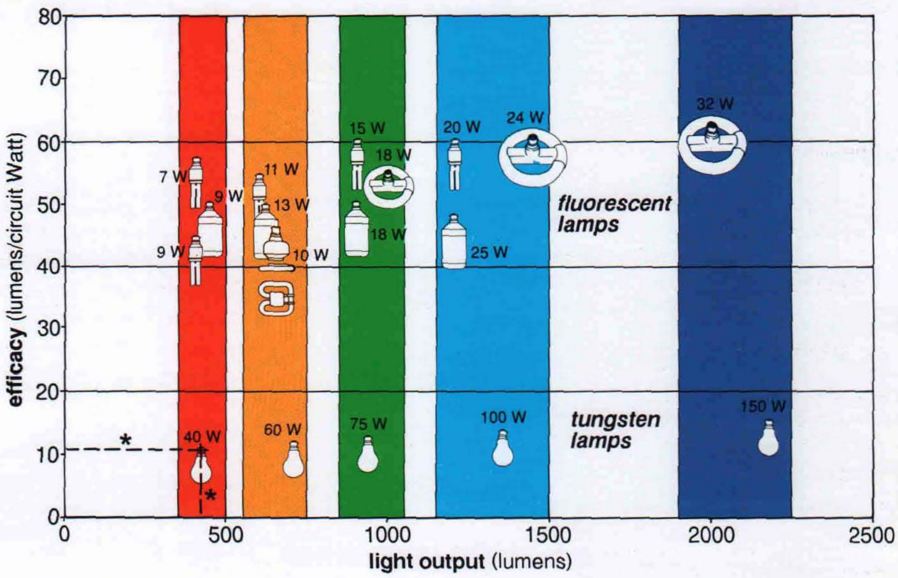
Savings of around 3% of your school's energy bill can result if someone is made responsible for switching lights off at break and lunch times and at the end of the school day. In some schools this is done by the caretaker, in others the pupils act as 'energy monitors'.

The use of automatic lighting controls, such as time switching and daylight sensors, can result in a further saving of around 5% of your energy bill. However, because of their cost and disruption during installation, the most suitable time to install automatic controls is when a school is being rewired. Rewiring also provides the opportunity to improve switching arrangements to maximise energy savings. For example, in some school buildings lights may only be switched in rows perpendicular to the windows. In this case, it is not possible to switch off lights near the window without depriving pupils at the back of the room. Better controls would allow groups of lights parallel to the window to be switched off when there is sufficient daylight.

	Area [m²]	Installed load [W/m²]	Hours of use per year [hr]	Energy * costs [£]
Assembly hall	200	15	800	168
Classrooms 1-4	280	22	1000	431
Classrooms 5-8	280	16	500	157
Shared teaching areas	240	12	600	121
Corridors and circulation areas	200	36	1200	605
Staff areas	80	32	1200	215
Kitchens	80	20	600	67
Store cupboards	40	40	100	11
Total annual lighting costs				**£1775**

* To obtain the energy costs, multiply the area by the installed load by the hours of use by the unit price of electricity (£0.07, divided by 1000). Eg 200 x 15 x 800 x 0.07/1000 = £168. (£0.07 is the approximate price of 1 kWh of electricity – if you have a more precise figure, use it here. Dividing by 1000 converts Watts to kW). Note that consistency is more important than absolute accuracy.

Table 1 Example of how to estimate annual lighting costs for a typical primary school



Notes: * The position of the cap indicates lamp efficacy and the level of light output

- *Lumens* are a measure of the quantity of visible light (luminous flux).
- *Lamp efficacy* is a measure of a lamp's light output (in lumens) in relation to its power input (in Watts).
- *Circuit Watts* is the term used to describe the total power consumption of a lamp, including its associated control gear.

Diagram 2 A comparison of tungsten and compact fluorescent lamps

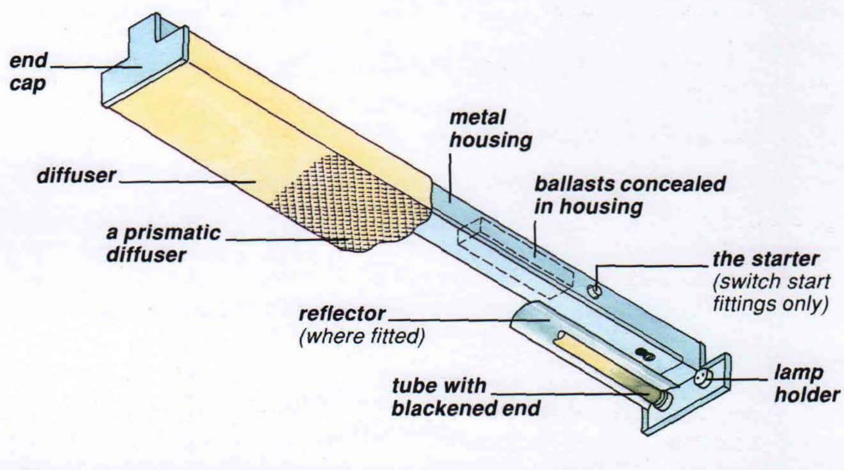


Diagram 3 The parts of a fluorescent light fitting

More efficient lighting

As can be seen from Diagram 1 there are wide variations in efficiency between different types of lamps and fittings.

The continuing improvement of lamps, control gear and fittings, means that a modern lighting installation can easily be twice as efficient as one that is 15 years old. If tungsten light bulbs are to be replaced by fluorescent lamps (compact or tubular) there will be an ideal opportunity to improve or optimise the lighting level in your teaching areas.

The Department for Education recommendation for fluorescent lighting in teaching areas is for a level of at least 300 lux on the working plane. Installing higher wattage tubular or compact fluorescent lamps than the tungsten equivalent may enable you to improve your lighting levels and save electricity. However, the light from compact fluorescent lamps may be different from that of tungsten bulbs. Therefore their characteristics and lighting levels should be verified prior to undertaking a replacement programme for the whole school.

There have been several significant developments in the design of fluorescent lamps and fittings that have increased their efficiency.

- The slimmer 26 mm diameter fluorescent tube. This gives the same light output as the traditional 38 mm tube, but uses about 8% less electricity. The 26 mm tubes can be used as direct replacements only in switch start fittings – see Diagram 3.
- Compact fluorescent lamps. These have been developed as an alternative to tungsten light bulbs. They use about 40 to 70% of the power of a tungsten bulb of similar light output and last up to eight times as long. They come in various shapes and sizes (see Diagram 2).
- High frequency (HF) ballasts. These consume up to 30% less energy than an equivalent 'switch start' fluorescent fitting with a conventional ballast. Operating lamps at high frequency has a number of other benefits, including better control of starting and operating conditions, an absence of flicker and a slightly reduced incidence of headaches and eye strain for people working under fluorescent lighting.

The efficiencies of other types of lamps have also improved. In particular, there have been major advances in high pressure sodium (called SON) lamps. SON lamps combine high light output and efficiency with reasonable colour rendering and a long lamp life. A number of different lamp types have been developed of which two are likely to be of interest to schools.

- SON De luxe lamps. The improved colour rendering of this new generation of SON lamps makes them ideal for assembly and sports halls.
- SON-H. These are specially developed plug-in replacements for 250 and 400 W high pressure mercury lamps, improving light output and efficiency without the expense of changing the light fitting or control gear.

Suggested improvements	Energy savings	Typical payback period
Replace tungsten lamps with compact fluorescent lamps, in the same fitting *	40-70%	Less than 2 years
Replace tungsten light fittings with new tubular fluorescent fittings, preferably with high frequency ballasts	50-70%	Between 2 and 5 years
For 'switch start' fluorescent fittings (see diagram 3), replace 38 mm diameter tubes with 26 mm diameter tubes as the former expire	8%	Immediate
For fluorescent lighting over 15 years old, either:		
replace existing ballast with high frequency ballast,	15-20%	Greater than 5 years
or replace fittings, preferably for ones with a high frequency ballast	25-55%	Greater than 5 years
For high pressure mercury (MBF) discharge lamps, either:		
replace lamps with 'plug-in' sodium lamps (SON-H) if the existing control gear is suitable,	15% (plus 35% increase in light output)	Less than 2 years
or if not, replace the fittings with new high pressure sodium (SON) De luxe lamps and fittings	Around 50%	Between 2 and 5 years
Install automatic lighting controls	20-50%	Between 2 and 5 years

Notes: Payback periods and savings will depend on the efficiency of the original installation, and on the hours of use assumed/estimated.

* This may not always be feasible because compact fluorescent lamps:

- do not always match exactly the light output and distribution of their tungsten equivalents (see Diagram 2);
- have shapes that may not fit into existing fittngs;
- can be too heavy for the existing fittings.

Experiment with a few different lamps before committing yourself to large scale replacement.

Table 2 Suggested improvements to existing lighting installations

New installations

If your school needs rewiring or is undergoing other refurbishment work, you should seriously consider whether your lighting installation needs to be upgraded. Table 2 sets out some suggested improvements that have been shown to be cost-effective in schools. In some cases, retaining the light fittings, but replacing the control gear can reduce running costs with the minimum of capital expenditure. Often, however, it will be more cost-effective to install new fittings. Each case should be evaluated on its merits by your local lighting specialist (see section on Further Advice).

A sensible refurbishment schedule would be to start with the lighting that has the highest installed load and is in use most often. For example, returning to analyse the figures in Table 1, two priorities emerge.

- The staff and circulation areas have high installed loads (they use tungsten lighting) and have long hours of use. Replacing the tungsten lamps with compact fluorescent lamps would produce an immediate reduction in energy costs of between 40% and 70%. Although the store cupboards also have tungsten lighting, they are a low priority because of the short hours of use.
- Classrooms 1 to 4 have a higher installed load than other teaching areas (because of a 20 year old installation that has 8 foot, 125 W fluorescent tubes) and high hours of use (because of overshading by nearby buildings). A new fluorescent lighting installation could cut energy costs by 50% or more. These classrooms should be the next priority.

Maintenance

Proper maintenance of light fittings may not directly result in energy savings, but will help to maintain good lighting levels (see Diagram 3). Attention should be paid to the following.

- Dirty reflectors and diffusers. The gradual accumulation of dust and dirt over a period of 10 years can reduce light output by 35%. Establish a regular cleaning programme, taking advantage of summer holidays to minimise disruption.
- Discoloured diffusers. The older type of opal plastic diffuser becomes discoloured with age and can absorb more than 50% of the light output from the tube. If this is the case, they should be replaced with new diffusers, preferably made from a clear prismatic material.
- Tubes with blackened ends. These are old tubes that are past their economic life (they carry on using the same amount of electricity, but give little light output). They should be replaced.

When going round the school, make an assessment of how clean the light fittings are and make a note of any fluorescent tubes with blackened ends. Fluorescent lamps will last many thousands of hours before finally failing, but as they age their light output gradually falls. By the time that a number of lamps in a room have failed, the light output from the others could well be half or less of that when new. In all but the smallest installation, it is sensible to replace the lamps at planned intervals rather than on a spot basis.

INFORMATION TECHNOLOGY

Information Technology (IT) equipment

Consumption of electricity in schools has shown a steady upward trend over the years. This can be largely explained by the increase in the use of computers and other IT equipment. Diagram 4 shows the electricity consumption of a range of IT equipment commonly found in schools.

Diagram 4 can help you to estimate the electricity used by computers and other IT equipment.

It shows:

- the relative consumption between different types of equipment;
- the average energy consumption when equipment is in use (shown by the blue bars);
- the energy that would be saved by switching off equipment when it is not in use (shown by the green bars);
- that nameplate ratings are generally much higher than the in-use consumption and are not a reliable indicator of power consumption.

For each type of equipment, the size of the nameplate rating provides little insight into whether it is likely to have a higher or lower than average in-use power consumption. Similar equipment with widely different nameplate ratings have almost identical in-use power consumptions.

The first step in estimating electricity consumption is to count the number of computers, printers etc and estimate the average number of hours that each item of equipment is switched on each day.

Type of equipment	Nameplate rating	Average power consumption [W] (scale: 0, 50, 100, 150, 200, 250, 500)
COMPUTER		
BBC (no VDU)	0.5 amp	18
IBM compatible	57-850 W (inc colour VDU)	85; 110 with hard disk
MONITOR/VDU		
Old mono	300 W	52
Modern mono	50 W	30
Old colour	1 amp (192 W)	95
Modern colour	60-95 W	50
PRINTER		
Daisy wheel	1-2 amps (168-336 W)	70
Dot matrix	0.5-0.85 amps (80-140 W)	50
	1-2 amps (168-336 W)	90
Laser printer	typically 850 W	120
TYPEWRITER		
Office machine	0.5 amp (70-95 W)	30
FAX MACHINE	65-250 W	14
PHOTOCOPIER		
Personal	5-8 amps (840-1 350 W)	120
Medium	6-11 amps (1 250-1 850 W)	200
Large capacity	8-11 amps (1400-1 850 W)	500

Key

- Green: Typical consumption when equipment switched on but not in use.
- Blue: Consumption with typical usage.

Notes

Information in this Table is based on measured consumption of equipment used in 18 offices.

Where nameplate ratings are in amps, the rating in Watts can be calculated by multiplying the current (amps) by 192 (240 volts x 0.8 power factor) for computers and by 168 (240 volts x 0.7 power factor) for other equipment.

Diagram 4 Energy consumption of IT equipment